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Global Positioning System

By George Parson

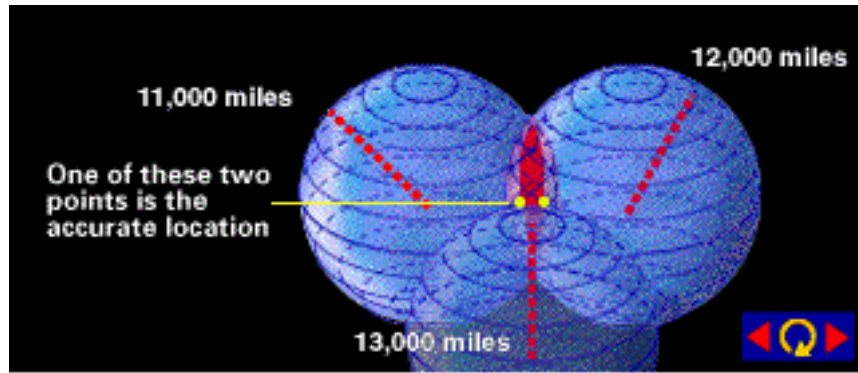
During the past decade many individuals, including myself, have believed that the Global Positioning System (GPS) would revolutionize the survey and mapping industry. Although the ability to navigate and position so easily and accurately has been a revolution, a whole host of technologies have been simmering in the background just waiting to be used. Although these technologies have been developing for a long time, GPS technology has been developing since the 1960's using vintage 1970's infrastructure. However, these technologies are quickly reaching maturity, allowing them to be used by the mapping industry to deliver spatial data to the public.

The GPS is a worldwide radio-navigation system formed from a constellation of 24 satellites and their ground stations. The GPS uses these "man-made stars" as reference points to calculate positions accurate to a matter of meters. In fact, with advanced forms of GPS you can make measurements with accuracy better than a centimeter! In a sense it's like giving every square meter on the planet a unique address.



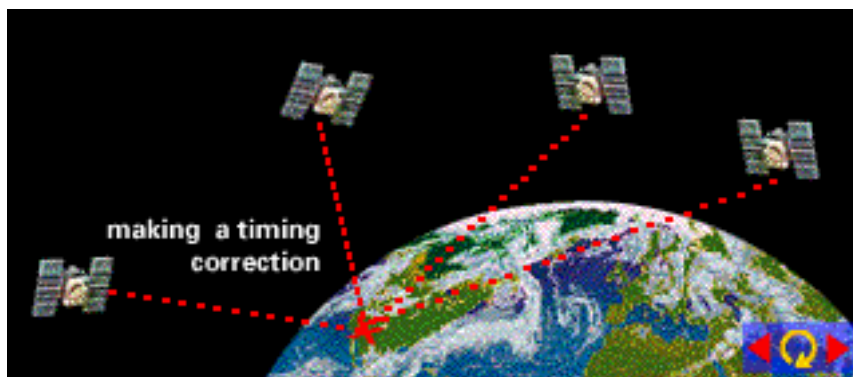
Federal Highway Administration





The GPS basically works by triangulation from the satellites. To triangulate, a GPS receiver measures distance using the travel time of radio signals. Therefore, GPS needs to very accurately measure time to calculate distance knowing the velocity of radio signals. It is also important to know exactly where the satellites are in space, which is achieved by using high orbits and carefully monitoring the location of each satellite. Of course the radio signals experience delays as they travel through the atmosphere, which means some corrections must be made to the GPS time calculations.

Mathematically, measurements are needed from four different satellites to determine exact positions for calculating distance measurements (ranges). Three ranges are enough to triangulate, but a fourth measure is used to correct for time discrepancy. Time measurements must be extremely precise because the measurements are very minute (hundredths and thousandths of a second.) The satellites have atomic clocks and the receivers get time signals from the satellites as part of the radio signal, so that each receiver does not need to have an atomic clock. This saves significant costs for receivers. In order to distinguish the GPS radio signals from all others, the signals are in a very complex digital code, known as Pseudo Random Code.



Since each satellite has its own unique Pseudo-Random Code, the receiver won't accidentally pick up another satellite's signal. So all the satellites can use the same frequency without jamming each other. In fact, the Pseudo Random Code gives the Department of Defense a way to control access to the system.

Of course it's not quite this simple because natural phenomena, electronic and mechanical variability, and human limitations all cause factors of error, and there are errors generated in the radio signals for security reasons called Selective Availability. For land survey, these errors must be compensated for with sophisticated hardware and software. Fortunately all of these inaccuracies don't add up to much of an error. A form of GPS called "Differential GPS" can significantly reduce these problems.

The GPS is revolutionizing the survey and mapping industry to increase productivity, improve accessibility, and with proper controls, accurately complete difficult projects. Enhancements are constantly correcting for the errors, and improving the output.

I received a request for survey and mapping of a 22.5-kilometer (14-mile) project on Annette Island in the southern part of Alaska while traveling in Montana August 22, 1996. I knew it was time to try GPS technology. The mapping had to be completed by December 1, 1996. Being familiar with the project area, I knew that the only chance of meeting this request was by using GPS controlled aerial photography. I contacted one of our architectural and engineering contractors the same day to see if they could put this mission together. On August 26, 1996, the mission was being put together with a subcontractor. A survey crew was on the project September 5, 1996. The crew of four people spent three weeks on the project, setting twenty-six targets and establishing GPS control on them. Access to the project was by boat, furnished by the Bureau of Indian Affairs, and then walking across the muskeg to the control points. The project was flown with a GPS receiver in the plane to provide precise position of the exposures as they were taken. The aerial mapping service then performed the aerial triangulation using the GPS data. The photography was received in our office on November 7, 1996 and our stereo plotter compiler completed the mapping on December, 6, 1996. The design was completed on June 9, 1997. The design line for the first phase of the project was staked using real time GPS. To date, two-thirds of the project has been staked using real time GPS.

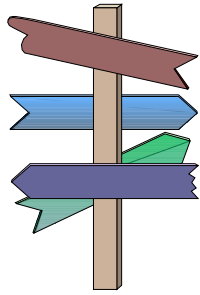
This project could not have been completed in the time frame required without using GPS controlled aerial photography. The cost for conventional controlled aerial photography for this project would have been three times what the GPS controlled aerial photography cost.

Since then, other projects have used GPS surveys with time and cost savings, easily justifying the cost of using this technology. As accuracy improves and equipment costs stabilize, we will be using GPS more frequently and routinely.

Soon Differential GPS may be able to resolve positions that are no farther apart than the width of your little finger. Automatic construction equipment could translate Computer Assisted Design (CAD) drawings into finished roads without any manual measurements. Imagine the possibilities.

Note:

There are several Web sites with information on GPS for those interested in learning more. One exceptional site is by Trimble Navigation Limited of Sunnyvale, CA, which was the source for equipment used on the Alaska project documented in this report. We gratefully acknowledge Trimble Navigation Limited as the graphics resource. You can visit the Trimble Web site at <http://www.trimble.com/gps/index.htm>.



Road Signs

Courage is resistance to fear, mastery of fear, not absence of fear.

– Mark Twain

We wish to thank all the individuals who have contributed articles for previous newsletters. If you are aware of a new technology, (or a fresh spin on an old one) please jot down your ideas and submit them via e-mail to me at the address below. Or, if you have an aversion to writing, just donate 15 minutes of your time for an interview (either by phone or in person), and I'll format the information for you. You can then review the article for accuracy (via e-mail or hard copy) and upon publication, you'll become famous in a matter of days. Remember, although we cater to road-related technology, ANY new technology information is welcome.

Please send all submissions to Kristi Swisher - (360.696.7572). Be sure your name, title, and phone number are the way you want them to appear in the article. Articles are subject to editor/ layout approval and may be condensed if space is limited.

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